Disclaimer:

Opinions expressed herein are those of the author, and not necessarily the CMS collaboration.

Frank Würthwein
UCSD
Overview

• Status of inclusive SUSY searches
• Status of SMS motivated SUSY searches
• Planning for the future

Throughout I will try to point out issues where we need help from pheno community
Evolution of SUSY Searches

Inclusive Signatures

Searches optimized for topologies

cMSSM

SMS

Searches optimized for holes in sensitivity

Full Models

This is (roughly) the progression both experiments are on.
Status of 8TeV Results for Inclusive Searches in CMS

<table>
<thead>
<tr>
<th></th>
<th>Without b-tags</th>
<th>With b-tags</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-leptons</td>
<td></td>
<td>20/ fb</td>
</tr>
<tr>
<td>1-lepton</td>
<td></td>
<td>20/ fb</td>
</tr>
<tr>
<td>2 leptons OS</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 leptons SS</td>
<td></td>
<td>11/ fb</td>
</tr>
<tr>
<td>&gt;= 3 leptons</td>
<td>9/ fb</td>
<td>9/ fb</td>
</tr>
<tr>
<td>1 photon</td>
<td>4/ fb</td>
<td></td>
</tr>
<tr>
<td>2 photons</td>
<td>4/ fb</td>
<td></td>
</tr>
</tbody>
</table>

We are still very far away from complete coverage !!!

Discuss these
$H_T$ vs MET vs b-tag fit

**Event sample legend**

- **ZL** = Zero Lepton; signal sample
- **SL** = Single Lepton; top & W+jets control sample
- **LDP** = low $\Delta \eta_{\text{min}}$; QCD control sample
- **Zee** = $Z \rightarrow e^+e^-$; Z to $\nu\bar{\nu}$ control sample
- **Zmm** = $Z \rightarrow \mu^+\mu^-$; Z to $\nu\bar{\nu}$ control sample

**Bin** | $H_T$ (GeV) | $E_T^{\text{miss}}$ (GeV)
---|---|---
1 | 400 – 500 (HT1) | 125 – 150 (MET1)
2 | 500 – 800 (HT2) | 150 – 250 (MET2)
3 | 800 – 1000 (HT3) | 250 – 350 (MET3)
4 | $> 1000$ (HT4) | $> 350$ (MET4)
H_{T} vs MET vs b-tag fit

CMS Preliminary, \( L_{\text{int}} = 19.4 \text{ fb}^{-1}, \sqrt{s} = 8 \text{ TeV} \)

- Unbiased fit
- Data
$H_T$ vs MET vs b-tag
Interpretation

CMS Preliminary, 19.4 fb$^{-1}$, $\sqrt{s} = 8$ TeV

$pp \rightarrow \tilde{g} \tilde{g}, \tilde{g} \rightarrow b \bar{b} \tilde{\chi}_1^0$
NLO-NLL exclusions

- Observed $\pm 1 \sigma_{\text{theory}}$
- Expected $\pm 1 \sigma_{\text{experiment}}$

95% C.L. upper limit on cross section (pb)
5 jets total of which 3 are b-tagged

HT = 1133 GeV
MET = 377 GeV
Large $H_T, \text{MET, jets, 1-lepton}$

- $\geq 6$ jets out of which $\geq 2$ are b-tagged
  - $p_T > 40\text{GeV}$, $H_T > 500\text{GeV}$
- 1 isolated $e$ or $\mu$ w. $p_T > 20\text{GeV}$
- Two Analyses:
  - “Lepton Spectrum” Method:
    - MET $> 250\text{GeV}$
    - Use lepton spectrum to predict bkg MET spectrum
  - “$S_T^{\text{lep}} \text{ vs } \Delta\phi(W,\text{lep})$” Method:
    - Bin in $S_T^{\text{lep}} = p_{T,\text{lep}} + \text{MET}$ for $\Delta\phi(W,\text{lep}) > 1$
    - Use $\Delta\phi(W,\text{lep}) < 1$ to predict bkg
Results for “$S_T^{lep}$” Method

<table>
<thead>
<tr>
<th>$N_{btag}$</th>
<th>$S_T^{lep}$ [GeV]</th>
<th>control reg. data</th>
<th>prediction</th>
<th>observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>[250,350]</td>
<td>141</td>
<td>$6.00 \pm 2.23 \pm 2.40$</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>[350,450]</td>
<td>24</td>
<td>$1.37 \pm 1.12 \pm 1.19$</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>$&gt;450$</td>
<td>9</td>
<td>$0.0 \pm 0.66 \pm 0.66$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>[250,350]</td>
<td>112</td>
<td>$3.83 \pm 1.75 \pm 1.84$</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>[350,450]</td>
<td>28</td>
<td>$2.74 \pm 1.86 \pm 2.02$</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>$&gt;450$</td>
<td>9</td>
<td>$0.0 \pm 0.42 \pm 0.42$</td>
<td>0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$N_{btag}$</th>
<th>$S_T^{lep}$ [GeV]</th>
<th>control reg. data</th>
<th>prediction</th>
<th>observation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\geq 3$</td>
<td>[250,350]</td>
<td>28</td>
<td>$1.92 \pm 0.84 \pm 0.95$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>[350,450]</td>
<td>13</td>
<td>$0.57 \pm 0.52 \pm 0.58$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>$&gt;450$</td>
<td>2</td>
<td>$0.0 \pm 0.22 \pm 0.22$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>[250,350]</td>
<td>45</td>
<td>$1.89 \pm 0.94 \pm 1.03$</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>[350,450]</td>
<td>7</td>
<td>$0.85 \pm 0.70 \pm 0.80$</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>$&gt;450$</td>
<td>0</td>
<td>$0.0 \pm 0.08 \pm 0.08$</td>
<td>0</td>
</tr>
</tbody>
</table>

No excess => setting limits !!!
Interpretation

CMS Preliminary \( \sqrt{s} = 8 \text{ TeV} \) 19.4 fb\(^{-1} \)

\( pp \rightarrow \tilde{g}\tilde{g}, \tilde{g} \rightarrow t\bar{t}\tilde{\chi}^0 \)

Single-lepton

\( N_{\text{jet}} \geq 6, \ N_b \geq 2 \)

NLO-NLL exclusions

\[ m(\tilde{\chi}^0) \] [GeV] vs \[ m(\tilde{g}) \] [GeV]

- \( \mathbb{E}_{T}+H_T \) Observed \( \pm 1 \sigma_{\text{theory}} \)
- \( \mathbb{E}_{T}+H_T \) Expected \( \pm 1 \sigma_{\text{experiment}} \)
- \( S_{T}^{\text{lep}}+\Delta\phi \) Observed \( \pm 1 \sigma_{\text{theory}} \)
- \( S_{T}^{\text{lep}}+\Delta\phi \) Expected \( \pm 1 \sigma_{\text{experiment}} \)
Comparison to other final states

\[ \tilde{g} \tilde{g} \text{ production, } \tilde{g} \rightarrow t \bar{t} \tilde{\chi}_1^0 \]
Inclusive 0- & 1-lepton analyses missing

- Lower MET && larger Njet
- Fewer or no b-tags
- Lower $H_T$ && fewer b-tags
- Lower MET && Lower $H_T$
- ...

Basically, analyses targeting stop, RPV, compressed spectra, SUSY without b-quarks

Even where we have 20/fb results, there is lot’s left to do.
Coverage in SMS RPC topologies

<table>
<thead>
<tr>
<th>Particle</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gluinos</td>
<td>(almost) ok</td>
</tr>
<tr>
<td>Squark</td>
<td>Ok</td>
</tr>
<tr>
<td>Stop</td>
<td>Incomplete</td>
</tr>
<tr>
<td>Sbottom</td>
<td>Ok</td>
</tr>
<tr>
<td>$X^+, X^0$</td>
<td>Incomplete</td>
</tr>
<tr>
<td>Sleptons</td>
<td>Incomplete</td>
</tr>
</tbody>
</table>

We have a good starting point, but are far from complete.

For overview of CMS@7TeV SMS results: 1301.2175
Aside on “Compressed Spectra”

Close to diagonal we trigger & select because of ISR jet production.

CMS Preliminary, √s = 8 TeV

N. Gev | A × ε
---|---
0 | 0
100 | 0.1
200 | 0.2
300 | 0.3
400 | 0.4
500 | 0.5
600 | 0.6
700 | 0.7
800 | 0.8
900 | 0.9
1000 | 1

pp → g, b → b b l

Jet 1

Cross section (normalised)

PM Matching
CKKW Matching
Parton Shower

ME+PS reduces uncertainties, but needs validation in data.

More details see M. Pierini at DESY workshop.
Two Examples to explain problems with SMS strategy

- SUSY with RPV
- Direct Stop production in RPC
• Three trilinear Yukawa couplings.
• Can result in a near infinitely diverse set of experimental observables.
• We pick illustrative examples rather than attempting completeness.
RPV Stop Decays

"Standard” stop to top $X^0$, followed by RPV $X^0$ decay

Searched for in $\geq 3$ leptons with $\leq 1$ hadronic tau.

LLE122 coupling
$e/\mu \ e/\mu \ \nu \ \text{top}$

LLE233 coupling
$e/\mu \ \tau \ \nu \ \text{top}$ .or. $\tau \ \tau \ \nu \ \text{top}$

LQD233 coupling
$e/\mu \ \text{bt t}$ .or. $\nu \ \text{bb t}$
≥3 leptons Analysis

- 20/10 $p_T$ $e^e/e^\mu/\mu\mu$ dilepton trigger
- Additional $e/\mu$ (tau) with $p_T>10$ (20)GeV
- At most one hadronic tau out of 3(4) leptons
- All leptons are prompt and isolated
- Distinguish 3 (4) leptons with/without tau
- Bin in $S_T = MET + H_T + p_T$ of leptons
- Distinguish Z to dilepton events
- Distinguish $≥1$ b-tag events
≥3 leptons Results

Choose $S_T$ binning to measure mass of stop irrespective of decay details.

$X^0$ masses 100 vs 1300GeV
for blue dashed vs solid
for stop mass 700 vs 1200GeV

<table>
<thead>
<tr>
<th>$N_{\ell}$</th>
<th>$N_T$</th>
<th>$0 &lt; S_T &lt; 300$</th>
<th>$300 &lt; S_T &lt; 600$</th>
<th>$600 &lt; S_T &lt; 1000$</th>
<th>$1000 &lt; S_T &lt; 1500$</th>
<th>$S_T &gt; 1500$</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0</td>
<td>0.186 ± 0.074</td>
<td>1.03 ± 0.22</td>
<td>0.19 ± 0.12</td>
<td>0.037 ± 0.039</td>
<td>0.000 ± 0.021</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0.89 ± 0.42</td>
<td>1.31 ± 0.48</td>
<td>0.39 ± 0.19</td>
<td>0.019 ± 0.026</td>
<td>0.000 ± 0.021</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>116 ± 50</td>
<td>127 ± 54</td>
<td>13 ± 5.6</td>
<td>1 ± 0.51</td>
<td>0 ± 0.096</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>710 ± 287</td>
<td>837 ± 423</td>
<td>83 ± 48</td>
<td>3 ± 3.9</td>
<td>0 ± 0.49</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$N_{\ell}$</th>
<th>$N_T$</th>
<th>$600 &lt; S_T &lt; 1000$</th>
<th>$1000 &lt; S_T &lt; 1500$</th>
<th>$S_T &gt; 1500$</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0</td>
<td>5 ± 2.6</td>
<td>2 ± 0.37</td>
<td>0 ± 0.113</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>2 ± 1.3</td>
<td>0 ± 0.34</td>
<td>0 ± 0.040</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>165 ± 53</td>
<td>21.4 ± 8.4</td>
<td>5 ± 0.99</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>276 ± 80</td>
<td>19.9 ± 6.8</td>
<td>0 ± 0.83</td>
</tr>
</tbody>
</table>

No Excess anywhere => Setting limits

4/23/13
≥3 leptons Results

LLE122 coupling
\( e/\mu \ e/\mu \nu \top \)

LLE233 coupling
\( e/\mu \tau \nu \top \) or \( \tau \tau \nu \top \)

Smaller eff. for tau => weaker limit!
≥3 leptons Results

Complicated BR x eff. => Complicated exclusion

<table>
<thead>
<tr>
<th>region label</th>
<th>kinematic region</th>
<th>stop decay mode(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$m_t &lt; m_{\tilde{t}} &lt; 2m_t, m_{\chi_1^0}$</td>
<td>$t \rightarrow tvb$</td>
</tr>
<tr>
<td>B</td>
<td>$2m_t &lt; m_{\tilde{t}} &lt; m_{\chi_1^0}$</td>
<td>$\tilde{t} \rightarrow t\mu\bar{b} + tvb\bar{b}$</td>
</tr>
<tr>
<td>C</td>
<td>$m_{\chi_1^0} &lt; m_{\tilde{t}} &lt; m_W + m_{\chi_1^0}$</td>
<td>$\tilde{t} \rightarrow \ell\nu b\bar{\chi}_1^0 + jjb\bar{\chi}_1^0$</td>
</tr>
<tr>
<td>D</td>
<td>$m_W + m_{\chi_1^0} &lt; m_{\tilde{t}} &lt; m_t + m_{\chi_1^0}$</td>
<td>$\tilde{t} \rightarrow Wb\bar{\chi}_1^0$</td>
</tr>
<tr>
<td>E</td>
<td>$m_t + m_{\chi_1^0} &lt; m_{\tilde{t}}$</td>
<td>$\tilde{t} \rightarrow t\bar{\chi}_1^0$</td>
</tr>
</tbody>
</table>

νbb dominates over e/µ bt in A,B and parts of E.

LQD233 coupling e/µ bt t .or. νbb t

Table 2: Kinematically allowed stop decay modes with RPV coupling

λ

( The allowed neutralino decay modes for $m_t < m_{\tilde{t}} < 2m_t$ are $\chi_{\tilde{t}} \rightarrow \mu t \bar{b} + \nu b \bar{b}$.

Figure 3: 95%CL limits for stop mass in models with RPV couplings $\lambda_{\tilde{t}}^{33}$, $\lambda_{\tilde{t}}^{233}$, and $\lambda_{\tilde{t}}^{22}$ with diagrams of the relevant RPV decays. For the couplings $\lambda_{\tilde{t}}^{22}$ and $\lambda_{\tilde{t}}^{233}$, the region to the left of the curve is excluded. For $\lambda_{\tilde{t}}^{233}$, the region inside the curve is excluded. The different regions on the $\lambda_{\tilde{t}}^{233}$ exclusion correspond to regions where the stop decays to different products and are explained in Table 2.
From 1209.0764

RPV stop decay
final states that we
(at the time) did not
cover well in either
ATLAS or CMS.

<table>
<thead>
<tr>
<th>Final state</th>
<th>$b$-jets</th>
<th>Scenario(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$(\tau^+\tau^-)$</td>
<td>0</td>
<td>LQD332</td>
</tr>
<tr>
<td>$(\tau^+\tau^-)$</td>
<td>0, 2</td>
<td>UDD312/323 with $H$ decaying via $t$; UDD213 with $H^\pm \to H^0$</td>
</tr>
<tr>
<td>$\ell^+\ell^- + 6j$</td>
<td>2, 4, 6</td>
<td>LQD232/233 with $H/W$ (unless decays via $b_L$ or $b_R$)</td>
</tr>
<tr>
<td>$\ell^+\ell^- + 6j$</td>
<td>2, 4</td>
<td>LQD221/123 with $W$</td>
</tr>
<tr>
<td>$\tau^+\tau^- + 6j$</td>
<td>2, 4, 6</td>
<td>LQD332/333 with $H/W$ (unless decays via $b_L$ or $b_R$)</td>
</tr>
<tr>
<td>$\tau^+\tau^- + 6j$</td>
<td>2, 4</td>
<td>LQD321/323 with $H-H_\nu/\bar{\tau}<em>L$ or $W$ (with or without $\chi</em>\pm \to \tilde{\chi}^0$)</td>
</tr>
<tr>
<td>$\tau^+\tau^- + 6j$</td>
<td>2, 4</td>
<td>LQD321/323 with $H-H_\nu/\bar{\tau}<em>L$ or $W$ with $\chi</em>\pm \to \tilde{\chi}^0$</td>
</tr>
<tr>
<td>$t\bar{t} + 6j$</td>
<td>2, 4</td>
<td>UDD212/213 with $\tilde{g}/B$; UDD213 with $H$</td>
</tr>
<tr>
<td>$t\bar{t} + 4j + \text{MET}$</td>
<td>2, 4, 6</td>
<td>LQD321/323 with $\tilde{g}/B$</td>
</tr>
<tr>
<td>$t\bar{t} + 4j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD321/323 with $\tilde{g}/B$</td>
</tr>
<tr>
<td>$(tt\text{ or } t\bar{t}) + 6j$</td>
<td>4, 6</td>
<td>UDD312/323 with $H^\pm \to H^0$</td>
</tr>
<tr>
<td>$t\bar{t} + 2\tau + 4j$</td>
<td>2, 4</td>
<td>LQD321/323 with $\tilde{g}/B$</td>
</tr>
<tr>
<td>$t\bar{t} + \tau + 4j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD321/323 with $H-H_\nu/\bar{\tau}_L$</td>
</tr>
<tr>
<td>$\tau^+\tau^-W^+W^- + 2j$</td>
<td>0</td>
<td>LQD321/323 with $\tilde{b}_R$</td>
</tr>
<tr>
<td>$\tau + W^+W^- + 2j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD221/123/321/323 with $W$</td>
</tr>
<tr>
<td>$\tau + W^+W^- + 2j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD321/323 with $W^\pm \to W^0$</td>
</tr>
<tr>
<td>$\tau + W^+W^- + 2j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD321/323 with $W^\pm \to W^0$ (unless decays via $\tilde{t}$)</td>
</tr>
<tr>
<td>$\tau + W^+W^- + 2j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD321/323 with $\tilde{b}_R$</td>
</tr>
<tr>
<td>$4 \text{ tops} + 4j$</td>
<td>4, 6</td>
<td>UDD312/323 with $\tilde{b}_R$</td>
</tr>
<tr>
<td>$6j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD221/123/321/323 with $W$</td>
</tr>
<tr>
<td>$6j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD321/323 with $W^\pm \to W^0$</td>
</tr>
<tr>
<td>$6j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD321/323 with $\tilde{b}_R$</td>
</tr>
<tr>
<td>$\tau + 6j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD321/323 with $\tilde{b}_R$</td>
</tr>
<tr>
<td>$\tau + 6j + \text{MET}$</td>
<td>2, 4</td>
<td>LQD321/323 with $\tilde{b}_R$</td>
</tr>
<tr>
<td>$\tau + 2b + \text{MET}$</td>
<td>2</td>
<td>LLE123/233 with heavy $W$</td>
</tr>
<tr>
<td>$W^+W^- + 4j$</td>
<td>0</td>
<td>UDD213 with $b_R$</td>
</tr>
</tbody>
</table>
Aside on Relationship between Pheno Community and Experiments

• Doing interpretations is a major effort for the experiments given their culture.
• What should the experiments do to enable interpretations by others?
• Is there a guiding principle towards what interpretations should be done inside versus outside the experiments?
Status of RPC Stop SMS

• Presently, ATLAS and CMS use:
  – “T2tt” = stop to top $X^0$ only for real top
  – “T2bw” = stop to $b$ $X^+$ followed by $X^+$ to $W$ $X^0$
    • Half a dozen different variants, all of which are essentially arbitrary and close to impossible to defend with a straight face.

• At the same time, the most serious low mass stop limit still comes from CDF.
  – Plus several phenomenology papers estimating the ATLAS and CMS exclusion:
    • 1211.2997, 1211.4981, 1212.6847, …
Example: 1211.2997

Reinterpreting ATLAS & CMS Monojet results assuming stop to $cX^0$ has BR = 100%

The only curve done by an experiment in this plot is CDF
What could we do that is defensible and complete?

How to pick relative BR?

- $t \rightarrow t* \chi^0$
- $t \rightarrow c \chi^0$
- $t \rightarrow W^*b \chi^0$
- $\tilde{t} \rightarrow t \chi^0$
- $\tilde{t} \rightarrow \tilde{c} \chi^0$
- $\tilde{t} \rightarrow \tilde{t} \chi^0$

Well motivated

Ok coverage

$\Delta m < m(W)$

$m(W) < \Delta m < m(t)$
Is there a limit to the usefulness of SMS?

Example from 1206.5800

If this is what a “typical” spectrum looks like, what’s the point of an SMS?
Options for Full Models

- **cMSSM**
  - Is this still worth doing?

- **pMSSM**
  - Plus: large “coverage”
  - Cons: not very efficient in providing models that
    - Satisfy naturalness criteria
    - Are consistent with higgs
    - Are consistent with dark matter abundance
    - Motivate anything other than all hadronic searches

- “Natural SUSY” subspace of pMSSM ?
- NMSSM ?
Looking Ahead

What is the HL-LHC physics objective?
What matters to CMS?
How can pheno help?

A personal perspective
Defining the “Future”

Several upgrades planned:

LHC:
- splice consolidation

L_{int}=50 \text{ fb}^{-1}

70\% nomimal luminosity

8 \text{ TeV} \rightarrow 13-14 \text{ TeV}


“Phase 0” Detector consolidation
CMS Pixel Upgrade “Phase 1”
“Phase 1” Upgrade
“Phase 2” Upgrade

Already planned, e.g. HCAL/Pixel/L1 TDR
Still to be defined...

L_{int}=300 \text{ fb}^{-1}

~ 5\times 10^{34} \text{ cm}^{-2}\text{s}^{-1}

L_{int}=3 \text{ ab}^{-1}

Courtesy of I. Gregor

(with lumi leveling)
Big Picture

• If we don’t see any new colored particles in 300/fb @ 14TeV then we won’t see any in 3000/fb either.

• Whatever limit the LHC can place on dark matter production sets the minimum energy scale worthwhile for the ILC.

To me this means there are 2 Questions worth asking.
Questions worth asking

• If we discover an excess in MET+Jets+btags (+lepton(s)) in 50/fb @ 13TeV, what phase 2 detector do we need to build to study this excess to understand what we have discovered?

• What is the discovery reach for pp → nothing?

We need help with the first question!
The help we need (I)

• First, let’s pick a “typical” natural susy spectrum that satisfies the constraints:
  – Higgs mass and other SM constraints
  – Dark Matter Abundance
  – Feature richness to motivate a wide range of detector upgrade studies.
Prototype Spectrum

- 3 Higgsinos $X^+, X_1^0, X_2^0$
- Trilepton
- $X_3^0$
- Stop 1
- Sbottom
- Stop 2
- Gluino

1500 GeV
1200 GeV
900 GeV
600 GeV
300 GeV

4/22/13
The help we need (II)

• What can we learn about the underlying physics of such a spectrum from measurements of the characteristics of the excess yield?
  – 2,4,6 b-quarks?
    • E.g. 2b + MET final state vs 4W + 2b + MET as indication of sbottom branching fractions?
  – Z’s vs Higgs vs γ in the cascades?
    • E.g. as indication of the nature of the neutralinos? tanβ?
  – 1,2,3,4 and more leptons?
    • E.g. presence or absence of low/high pT leptons as indication of mass splittings between particles that decay into each other by emitting a W?
      – Muons (electrons) down to 5 (10) GeV
    • Same-flavor dileptons below the Z mass as signature of mass differences?
  – Boosted hadronic decays of W’s or top’s as signature of large mass splittings?
  – Can we distinguish tanβ ~ O(1), O(10), O(100), or even better?
  – Anything else you can think of!!!
Conclusions

• Anybody who tells you the LHC is done with its 8TeV searches is just plain wrong. We got lot’s of work left to do !!!
• What part of the interpretations program should we leave for the pheno community?
• We need help with charting the course for the future !!!